

GENERAL CHEMICAL (SODA ASH) PARTNERS

ENVIRONMENTAL DEPARTMENT

FAX COVER SHEET

TO: Dolly Potter (Solvay) 872-5876
FROM: Mike Dahl
SUBJ: BACT Analysis (Wet Elec. Precip.)
DATE: 7/21/97

TOTAL PAGES INCLUDING COVER SHEET: 10

COMMENTS/REMARKS: Is this what you
needed. Call back if more info
required.

Mike
872-3445 (Phone)
872-3606 (Fax)

ENSR

Source-specific factors were considered in the estimation of capital and operating costs for catalytic oxidation. As with thermal oxidizers, the calciner exhaust flow rate would need to be supplemented with a significant volume of auxiliary combustion air due to the low oxygen content of the waste gas. In addition, the waste gas contains significant levels of particulate matter (13 lb/hr); as a result, the expected catalyst life was assumed to be two years.

4.8.1 Economic Impacts

Table A-5 through A-8 (Appendix A) present capital and annual operating costs for catalytic incinerators having heat recoveries of 70, 50, 35, and 0 percent. For each of these designs, the assumed 95 percent control efficiency resulted in potential VOC emissions reductions of 93 to 95 tpy. The total capital costs ranged from \$1,500,000 (0 percent heat recovery) to \$2,100,000 (70 percent heat recovery). The estimated annual operating costs were between \$950,000 (70 percent heat recovery) and \$1,250,000 (0 percent heat recovery). The resulting cost effectiveness levels were between \$10,000 per ton and \$13,600 per ton. These cost effectiveness values are too high to be considered economically feasible, since their predicted economic impacts are excessive.

4.8.2 Catalytic Oxidation Summary

Due to the extremely adverse economic impacts of catalytic oxidation, this technology is not considered BACT for the application in question. While not fully evaluated, adverse energy and environmental impacts also would be associated with this control alternative. Electricity and natural gas costs would range from approximately \$330,000 to more \$745,000 per year, and spent catalyst may require handling and disposal under hazardous waste regulations.

4.9 Wet Electrostatic Precipitator

Wet electrostatic precipitators (WESPs) were introduced as control devices in the 1970s to reduce emissions of sub-micron size particles. They also control condensable organics, especially those that are soluble. The WESP is a particulate and liquid mist control device, which requires that process gases be cooled to 110-120 F in order to achieve the required condensation of the contaminants. The exhaust stream is pretreated in a quencher, saturated with water, and cooled to the required level, forming a dense mist of very small droplets. The droplets absorb the contaminants in the stream, at varying efficiencies dependent on the species, solubility, and on the temperature. The gas enters the upper plenum of the device, and travels downward (In some designs the gas flows upward.) through a number of cylindrical collecting tubes. In the center of each tube is a high voltage discharge electrode, that when energized emits an electric corona field. The particles passing through this field attain a negative charge

ENSR

and migrate over to the collecting tube wall, which is grounded. The fine water droplets generated in the preconditioner will also be charged and migrate to the wall. The collected water forms a film of liquid that runs down the collective tube, providing continual cleaning of the tube wall. While on-line the WESP may be cleaned with a wash down cycle.

For purposes of this evaluation, the WESP is assumed to be able to collect a fraction of only the condensible organics. Non-condensable organics, including some VOCs will not be controlled by this device. No vendor guarantee was obtained for the percentage control of organic materials for this system. For this reason, we have assumed that only the portion of the condensible organics will be controlled by this apparatus. The most recent test of condensible organics, using a back-half Method 5/202 sampling train, reported emissions on the GR-2-C calciner in April 1997, with a total emission rate of 9.59 lb/hour, or equivalently 42.0 ton/year of condensibles. Since the sampled organics are collected at a temperature of about 32 F, and the WESP is controlling organics at a temperature of about 110 F, the use of the sampled emission rate of condensible organics will represent a vast overestimate of the amount of organics controlled. The sample train is simply "condensing" more of the organic material than would the WESP under normal operations. For purposes of calculating control effectiveness, we will assume a 95% control of the condensible organics (9.11 lb/hour or 40 ton/year). It is a serious overestimate of the effectiveness of this system to not account for the difference in condensibles at 32 F and 110 F; but without further information such an estimate cannot be made.

Based on vendor information, the existing maximum flow rate for the calciner (60,000 acfm) is slightly above the design flow rate range (3,000 to 50,000 acfm) for the WESP for each module. However, for purposes of this analysis, we have assumed that one module can be installed to control each calciner. As noted in the analysis, the WESP has a high water demand, estimated at 2 to 6 gallons/hour (5 gal/hour was assumed here) for each 1000 acfm of the flue gas emission rate, in the vendor information, and calculated at 300 gallons/hour in order to cool the calciner exhaust gas stream to the required temperature. Also, it is possible that the WESP discharge liquid may contain hazardous organic chemicals, requiring special treatment; however, that factor has not been analyzed in this report.

The installation of WESPs at the Green River works would require several capital/construction projects to support their operation, which are unique to the General Chemical facility and its location. The volume of water discharged from the WESP would require the installation of a lined evaporation pond, because at current operations the existing pond system is at its capacity to receive the wastewater. The installation of these units would also require construction of a heated building to contain the WESP structures, largely to control potential for system freeze-up in winter, and to ensure that the condensed materials do not clog or inhibit the flow of the WESP. The accretion of the organic materials will also pose a safety hazard with potentials for fires,

ENSR

similar to the collection of any combustible materials in the process stream. A heated building will also inhibit the collection of these materials, and would be required for purposes of safe operations. The installation of these supporting structures has not been included in the cost analysis at this time.

4.9.1 Economic Impacts

The attached Table 1 provides the capital and operating costs for the WESP installation for the GR-2 calciners, at 65 tph production rate, including the installation of the CHELs. A control effectiveness of 95% has been assumed as well. Original capital costs were based on estimates provided by Air Pol for a commercially available WESP. The costs for the water use and treatment have been included in the cost analyses; however, the costs do not include any special treatment for potentially hazardous waste water, which may be generated by the WESP from the collection of hazardous organics. Plant specific cost factors are identical to those used in the analysis of other control devices. As noted in the table, the total annualized cost, including an assumption of a 10 year life and 10 percent interest, is \$430,600, including both the capital and annual operating costs.

The construction of the required supporting projects, including the lined evaporation pond and the heated building have not been included in this analysis at this time. Costs of these structures will be substantial and will require a considerable engineering and design effort to obtain a reliable cost. Given the other costs that are tabulated below, it is very conservative at this time to analyze the cost effectiveness of the WESP as BACT without such considerations, because the other costs already drive the WESP effectiveness costs above the commonly accepted thresholds. If suitable, however, the building and pond costs can be determined, which will add costs and further reduce the cost effectiveness of WESPs.

At 40 ton/year controlled VOCs, the cost effectiveness is calculated at \$10,800 per ton of organics removed. This value is considered well above the commonly accepted cost effectiveness factors, and is in fact equivalent to or slightly more costly than the regenerative thermal oxidizers and the catalytic oxidizers (which varied from \$8,800 to \$10,700 per ton controlled). The incremental increases in organic condensibles, associated with increasing production from 52.5 tph to 65 tph, is estimated at 7.7 ton/year (40 ton/year X 12.5 tph increase/65 tph design). The cost for the incremental controls is \$55,900 per ton of organics controlled. Again this incremental value is extremely high and is higher than the effectiveness of other control devices.

4.9.2 Energy and Environmental Impacts

The WESP operation will require approximately 2.6 million gallons/year of water for each calciner (13 million gallons/year for all five GR-2 calciners), with a substantial portion of that water evaporated directly into the exhaust gas stream, in order to cool the exhaust gases. There are several serious environmental effects that will result.

- Substantial water usage will place secondary burdens on the environment, thereby depleting the availability of fresh water for other environmentally sensitive needs, such as stream flow.
- A substantial wastewater stream will be generated, requiring treatment, which at the Green River Works would imply the expansion or installation of additional evaporation ponds. The generation of significant additional wastewater is a serious environmental adverse effect.
- The wastewater will contain organic materials that may also need additional controls. It is possible that the use of the WESP will simply transfer the emission of organics from the atmosphere to a wastewater discharge, and potentially back to the atmosphere through the use of the ponds. There would be no environmental benefit from transferring the emissions from the calciner exhaust gas stack to the evaporation from the pond. At least a portion of the collected organics will be emitted from the wastewater treatment system.
- The substantial steam plume may also create added fogging during the colder winter months and on cooler mornings. Essentially a supersaturated exhaust stream will be emitted and will be visible considerably more often than is the current, drier plume. While the plume will be primarily an aesthetic impact, a safety hazard could result for plumes which form icing or which impact the ground near the plant.

The use of the WESP also requires substantial electrical consumption., estimated at over 350,000 kwh per year for each calciner. Non-renewable energy resources will be expended to meet this demand, and direct adverse environmental effects associated with the generation of this electric power will also result.

There are significant environmental and energy costs associated with the use of the WESP, and the system can be rejected as BACT, based on the adverse environmental costs and on the energy demands as well.

ENSR

4.9.3 WESP Summary

This device has not been installed or operated on similar calcining units. No control effectiveness for organic or VOC emissions from these type of units is available. Due to the lack of a demonstrated performance for controlling organic emissions from calciners, the high cost of controlling condensible organics, and due to the adverse environmental and energy impacts from its use, the installation of a WESP to control organic emissions from the modified calciners is rejected as BACT.

4.10 High Temperature/Residence Time Combustion

The current operation of the General Chemical calciners incorporates good combustion control at high temperature and residence time. These operating conditions are based on "good combustion practice" procedures followed by General Chemical, and include the exclusive firing of natural gas.

The calcining operation acts as a control on organics emitted from ore processing. In the calcining operation, ore materials are raised to a temperature of 160° to 180°C, which meets the requirements of a calcining operation and oxidizes the bulk of the ore-bound organic compounds.

4.11 Summary of BACT Analysis

Utilizing U.S. EPA top-down guidelines for BACT analysis, the use of high temperatures and high residence time combustion the calciners was determined to be BACT. Add-on control alternatives were considered, but were found to be economically infeasible. As shown in Table 4-5, the cost effectiveness of add-on control technologies was estimated between \$8,800 and \$25,300 per ton of VOC potentially controlled. In addition, adverse energy and environmental impacts were determined to be associated with the available add-on control alternatives. The incremental cost effectiveness, based on the annual cost to control VOC increases resulting from the calciner modification only, were between \$55,900 and \$218,000 per ton.

ENSR

The control alternative proposed as BACT for VOC emissions from the modified calciners is *high temperature and high residence time combustion*. This alternative results in a maximum emission rate of 101 tpy per calciner, and a maximum VOC increase of 11.7 tpy per calciner. This alternative is economically feasible, and does not increase energy usage. In addition, this alternative results in none of the adverse environmental impacts associated with the add-on technologies described in this report (e.g., increased NO_x, CO and PM₁₀ emissions, water usage and wastewater treatment, and waste disposal).

2999-007

4-18

June 1997

11 2

10 8

1 3

4-15

SOLVAY2016_1.4_001508

Capital Costs of Air Pol Wet ESP

General Chemical Green River Works for GR-I, II Calciners

Item	Value	Basia
Direct Costs		
1.) Purchased Equipment Cost		
a.) ESP + auxiliary equipment	\$344,600	Scaled Air Pol Quotation, A
b.) Instrumentation	\$34,500	0.10 x A
c.) Sales taxes	\$10,300	0.03 x A
d.) Freight	\$17,200	0.05 x A
Total Purchased equipment cost, (PEC)	\$406,600	B = 1.18 x A
2.) Direct installation costs		
a.) Foundations and supports	\$32,500	0.08 x B
b.) Handling and erection	\$61,000	0.15 x B
c.) Electrical	\$40,700	0.10 x B
d.) Piping	\$81,300	0.20 x B
e.) Insulation for ductwork	\$40,700	0.10 x B
f.) Painting	\$4,100	0.01 x B
Total direct installation cost	\$260,300	0.64 x B
3.) Site preparation	NA	As Required, SP
4.) Buildings	NA	As Required, Bldg.
Total Direct Cost, DC	\$666,900	1.84B + SP + Bldg.
Indirect Costs (Installation)		
5.) Engineering	\$162,800	0.40 x B
6.) Construction and field expenses	\$162,600	0.40 x B
7.) Contractor fees	\$20,300	0.05 x B
8.) Start-up	\$4,100	0.01 x B
9.) Performance test	\$10,200	0.025 x B
10.) Bond and Sales Tax	\$12,200	0.03 x B
Total Indirect Cost, IC	\$372,000	0.915 x B
11.) Contingencies	\$155,800	0.15 x (DC + IC), Cont.
Total Capital Investment (TCI) = DC + IC + Contingencies	\$1,194,700	2.555B + Cont. + SP + Bldg.

Table A-8b
Annualized Capital and Operating Costs for Air Pol Wet ESP
General Chemical Green River Works for GR-I, II Calciners

Item	Value	Basis	Source
1) Electricity			
Press. Drop (in. W.C.)			
Fan Power (kW)			
ESP (kW)			
Energy (kWh)	350,400	40 kW for wet ESP	Vendor Data
Unit Cost (\$/kWh)	0.024	Facility Data	Facility Data
Cost (\$/yr)	\$8,410		
2) Operating Labor			
Requirement (hr/shift)	2	2 hrs per shift	OAQPS, 1990
Unit Cost (\$/hr)	\$21.21	Industry Averages	OAQPS, 1996
Cost (\$/yr)	\$46,320		
3) Supervisory Labor			
Cost (\$/yr)	\$6,950	15% Operating Labor	OAQPS, 1990
4) Maintenance			
Labor Req. (hr/shift)	2	2 hours per shift	OAQPS, 1990
Unit Cost (\$/hr)	\$22.28	Industry Averages	OAQPS, 1996
Labor Cost (\$/yr)	\$48,680		
Material Cost (\$/yr)	\$4,068	1% of Wet ESP Equipment Cost	Valavuk, 1991
Total Cost (\$/yr)	\$52,730		
5) Water Consumption			
Requirement (thousand gal/yr)			
Unit Cost (\$/thousand gal)	2.628	5 gph/1000 acfm	Vendor Data
Total Cost (\$/yr)	2.00	Cost of process water, dry region	Facility Data
6) Wastewater Treatment			
Wastewater Treatment (thousand gal/yr)			
Treatment Cost (\$/thousand gal)	2.628	non-hazardous wastewater	Wash water consumed
Cost (\$/yr)	\$1.82	Cost of water treatment, dry region	Facility Data
7) Indirect Annual Costs			
Overhead	\$4,780		
Administration	\$63,800	60% of O&M Costs	OAQPS, 1990
Property Tax	\$23,890	2% of Total Capital Investment	OAQPS, 1990
Insurance	\$11,950	1% of Total Capital Investment	OAQPS, 1990
Capital Recovery	\$11,950	1% of Total Capital Investment	OAQPS, 1990
Total Indirect (\$/yr)	\$194,740	10 yr life, 10% interest	OAQPS, 1990
Total Annualized Cost (\$/yr)	\$306,130		
Total VOC Controlled (t/yr)	430,800		
Cost Effectiveness (\$/ton)	40.0		
	10,800		

Summary of Control Technology Cost Analyses
Table 4-5

COST PARAMETERS			REFRIGERATED		CARBON		CATALYTIC		CATALYTIC		CATALYTIC		Wet ESP
			CONDENSER	RTO - 85%	RTO - 95%	ADSORPTION	OXID - 70%	OXID - 50%	OXID - 35%	OXID - 0%			
CAPITAL COSTS													
DIRECT COSTS													
Purchased Equipment													
Basic Equipment and Auxiliaries			\$2,724,882	Included	Included	\$2,384,272	Included	Included	Included	Included	Included		\$344,600
Instruments and Controls			\$272,488	In total	in total	\$238,427	below	below	below	below	below		\$34,500
Freight and Taxes			\$183,493	Capital	capital	\$143,056							\$10,340
Total Equipment Cost			\$3,180,863	Investment	Investment	\$2,765,755	\$1,094,381	\$987,913	\$687,811	\$781,327			\$406,800
				(below)	(below)								
Construction Costs													
Foundations and Supports			\$252,869	Included	Included	\$221,280	Included	Included	Included	Included	Included		\$32,500
Erection and Handling			\$474,129	In total	in total	\$414,863	In total	In total	In total	In total	In total		\$61,000
Electrical			\$316,088	Capital	capital	\$276,578	capital	capital	capital	capital	capital		\$40,700
Piping			\$632,173	Investment	Investment	\$553,151	Investment	Investment	Investment	Investment	Investment		\$81,200
Insulation			\$316,088	(below)	(below)	\$276,578	(below)	(below)	(below)	(below)	(below)		\$40,700
Painting			\$31,609			\$27,858							\$4,100
Total Construction Costs			\$2,022,953			\$1,770,083							\$688,900
Total Direct Costs			\$5,183,816			\$4,535,839							
INDIRECT COSTS													
Indirect Field Costs			\$1,089,953	Included	Included	\$953,709	Included	Included	Included	Included	Included		\$162,600
Contractor Fees			\$138,244	In total	in total	\$119,214	In total	In total	In total	In total	In total		\$20,300
Engineering			\$1,089,953	Capital	capital	\$953,709	capital	capital	capital	capital	capital		\$162,600
Bond and Sales Tax			\$91,746	Investment	Investment	\$71,528	Investment	Investment	Investment	Investment	Investment		\$12,200
Start-up			\$27,248	(below)	(below)	\$23,843	(below)	(below)	(below)	(below)	(below)		\$4,100
Performance Test			\$68,122			\$59,607							\$10,200
Total Indirect Costs			\$2,483,287			\$2,181,609							\$372,000
Contingency			\$1,151,562			\$1,007,617							\$153,600
TOTAL CAPITAL INVESTMENT			\$5,183,816	\$1,999,602	\$2,467,127	\$7,725,085	\$2,079,124	\$1,638,641	\$1,325,701	\$1,503,362			\$1,194,700
ANNUAL COSTS													
Operating labor			\$48,450	\$48,450	\$48,450	\$48,450	\$46,450	\$48,450	\$46,450	\$46,450			\$46,320
Supervisory labor			\$6,967	\$6,967	\$6,967	\$6,967	\$6,967	\$6,967	\$6,967	\$6,967			\$6,950
Maintenance labor			\$24,397	\$18,537	\$18,537	\$24,397	\$24,387	\$24,397	\$24,397	\$24,397			\$24,680
Maintenance materials			\$24,397	\$18,537	\$18,537	\$24,397	\$24,397	\$24,397	\$24,397	\$24,397			\$4,868
Natural gas			na	\$358,875	\$176,771	na	\$287,290	\$388,668	\$497,552	\$727,814			na
Electricity			\$15,818	\$462,442	\$48,250	\$68,721	\$64,694	\$40,308	\$30,952	\$21,978			\$8,410
Steam			na	na	na	\$11,538	na	na	na	na			na
Carbon/catalyst replacement			na	na	na	\$1,182	\$40,990	\$41,102	\$41,165	\$41,270			na
Waste disposal			\$200,940	na	na	\$334,860*	na	na	na	na			\$4,780
Overhead			\$48,688	\$54,295	\$54,295	\$46,688	\$61,328	\$81,328	\$81,328	\$81,328			\$83,900
Taxes, insurance, administrative			\$353,146	\$79,982	\$88,685	\$309,003	\$83,165	\$73,554	\$53,028	\$60,134			\$47,790
Capital recovery			\$1,436,821	\$325,459	\$401,565	\$1,257,218	\$325,864	\$264,725	\$203,166	\$232,042			\$194,740
TOTAL ANNUAL COST			\$2,155,424	\$955,537	\$889,057	\$2,438,218	\$945,540	\$1,004,081	\$969,443	\$1,246,863			\$430,600
COST EFFECTIVENESS													
Uncontrolled VOC Emissions (tpy)			101	101	101	101	101	101	101	101			42
Control Efficiency			89%	98%	98%	95%	85%	85%	95%	95%			85%
VOC Controlled (tpy)			100	97.3	98.4	96	95	94	93	92			40
Cost Effectiveness (\$/ton)			\$21,453	\$9,825	\$8,624	\$25,271	\$9,977	\$10,888	\$10,598	\$13,581			\$10,800
Incremental VOC increases (tpy)			11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7			8.1
Incremental VOC Controlled (tpy)			11.8	9.3	10.4	11.2	9.5	8.7	8.7	8.7			7.7
Incremental Cost Effectiveness (\$/ton)			\$185,478	\$102,724	\$83,314	\$218,481	\$99,408	\$115,354	\$122,188	\$188,481			\$55,900

* Cost for wastewater treatment - does not include construction of WWTP facility